NPS54-82-003

NAVAL POSTGRADUATE SCHOOL

Monterey, California

EVALUATION OF SECNAVINST 3560.1 TACTICAL
DIGITAL SYSTEMS DOCUMENTATION STANDARD
FOR SOFTWARE MAINTENANCE

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February 1982

Final Report: 1 Jan 80 to 1 Jan 82

Prepared for:
The Trident Command and Control Systems
Maintenance Agency
Newport, Rhode Island

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The work reported herein was supported by the Trident Command and Control Systems Maintenance Agency.

This report was prepared by:

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NPS54-82-003
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): EVALUATION OF SECNAVINST 3560.1 TACTICAL DIGITAL SYSTEMS DOCUMENTATION STANDARD FOR SOFTWARE MAINTENANCE

5. TYPE OF REPORT & PERIOD COVERED: Final Report 1 Jan 80 to 1 Jan 82

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Norman F. Schneidewind

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Postgraduate School, Monterey, California 93940

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: N4216680WR00007

11. CONTROLLING OFFICE NAME AND ADDRESS: Trident Command and Control Systems Maintenance Agency, Newport Rhode Island 02840

12. REPORT DATE: 22 February 1982

13. NUMBER OF PAGES: 27

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report):

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):

18. SUPPLEMENTARY NOTES:

19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
Software maintenance
Software maintainability
Software standards
SECNAVINST 3560.1
Traceability

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

Management and developers have given insufficient attention to software maintenance, the most expensive phase of the software life cycle. Standards have improved the ability to develop and design software, but most standards do not deal with the maintenance phase in a substantive way. SECNAVINST 3560.1, Tactical Digital Systems Documentation Standard for Software Maintenance, was evaluated with respect to its usability for software maintenance. Recommendations are made for improving the maintainability aspects of this instruction.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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I. INTRODUCTION

Trident CCSMA has requested the Naval Postgraduate School to evaluate the Department of the Navy's Tactical Digital Systems Documentation Standard SEGNAVINST 3560.1 dated 8 August 1974, hereafter referred to as 3560.1, with respect to its applicability and usefulness for software maintenance. This report is divided into the following sections:

- Brief Description of 3560.1. This section is provided to give the reader who is unfamiliar with 3560.1 a brief overview of its contents.
- Traceability. Since a major concern of CCSMA is traceability, 3560.1 is evaluated with respect to its traceability attributes. Traceability exists when it is possible to identify the parts of the software system, and the corresponding documentation, that will be affected by a change in the software stemming from a software error correction or enhancement.
- Usefulness of 3560.1 for Supporting Software Maintenance. Each section of 3560.1 that is applicable to software maintenance is examined with respect to usefulness for maintenance.
- Conclusions and Recommendations. Major conclusions concerning the adequacy of 3560.1 for software maintenance are drawn and recommendations are made to make it more suitable for this activity.

The major conclusion of this report is that, as it stands, 3560.1 is inadequate for effectively supporting a software

maintenance activity. However, with the improvements that have been recommended, 3560.1 could be the equal of recently announced tactical software standards.

II. BRIEF DESCRIPTION OF 3560.1

1. Tactical Operational Requirement (TOR)
   - Tactical digital system functional requirements.
   - Serves as a basic software specification for design and program implementation.
2. System Operational Specification (SOS)
   - Specific operations desired from application of the digital processor supported data system.
3. System Operational Design (SOD)
   - Plan for integrated system program.
   - Program functions, core allocations, subprogram definitions and interfaces, program data storage plans, and support programs.
   - I/O channel assignments.
   - Data to be exchanged between digital processors and peripherals.
   - Timing requirements for messages.
4. Function Operational Specification (FOS)
   - Design of each separate data function.
   - Specify each required action at each operator's position.
5. Interface Design Specification (IDS)
   - Specifications for interdigital processor message traffic in format and content.
6. Program Performance Specification (PPS)
   - Describes performance requirements for the computer programs of the digital processor system.

- Baseline for configuration control.
- Controlling document for procuring agency.

7. Function Operational Design (FOD)
   - Program performance design in operator function terms for each operator and peripheral equipment.
8. Program Design Specification (PDS)
   - Design details for digital processor programs in programming language.
   - Used for program maintenance.
9. Program Description Document (PDD)
   - Design details for each subprogram.
10. Data Base Design (DBD)
    - Detailed description of all data items.
11. Program Package (PP)
    - Card decks, tapes, listings, etc.
12. Test Plan (TPL)
    - Defines the scope of tests required to ensure that the system, function and program meet all applicable technical, operational, and performance specifications.
    - Establishes detailed acceptance criteria for the system and identifies each level of testing.
13. Test Specification (TS)
    - Purpose and scope of test.
    - Identifies software, hardware, and system to be tested.
14. Test Procedure (TPP)
    - Instructions for test execution and evaluation of results.

15. Test Report (TR)

- Describes and evaluates discrepancies between program design and operation.

16. Operator's Manual (OM)

- Presents procedures for prestandby, operate, monitoring, and recovery of the digital processor program.
- Describes the minimal operating environment.

17. Program Design Manual (PDM)

- Provides the theory of combat direction system program processes that support the station operator.
- By operator and equipment function, describes the digital processor program logic and algorithms that produce actions and data displays for the operator.

18. Command and Staff Manual

- Provides a nontechnical description of the tactical system.
- Addresses the mission, characteristics, employment, capabilities and limitations of the tactical system.

19. System Operator's Manual

- Sole reference for individual operator duties and station function.
- Explains, at the level required by system operators, every control button, switch, readout, and display affected by the system program.

III. TRACEABILITY

In order to illustrate the traceability characteristics of 3560.1, TABLE 1 is provided to show the specific references which a given section of 3560.1 (e.g., SOS) makes to the other section(s) (e.g., TOR). Where these references occur, an "X" is placed in the appropriate cell of TABLE 1. The table is read by interpreting the left-hand column as the section in which a reference occurs, and the top row, where there is an "X" in a cell, to be a referenced section. The resultant matrix indicates the degree of traceability that exists in the standard. That is, the density or sparseness of the matrix is one measure of the existence or absence of traceability, respectively.

The desired traceability relationship, as implied ty "TDS Documentation Relationship," Figure 2 on page 6 of 3560.1, is shown in FIGURE 1. The chart (FIGURE 1) was derived from Figure 2 of 3560.1 by considering only those sections of the standard that are concerned with program development, design, and testing, The arrows are upward pointing to suggest the use of documentation for traceability purposes. For example, in FIGURE 1, a Test Report (TR) can be traced to the Tactical Operational Requirement (TOR). The actual traceability relationships, as defined by TABLE 1 for the documents shown in FIGURE 1, are shown in FIGURE 2. Although a great deal of traceability capability exists in 3560.1, a comparison of FIGURE 1 with FIGURE 2 shows that actual traceability is less than desired traceability, thus indicating inconsistencies between the objectives of the standard, relative to traceability, and the actual content of its various sections.

Although it is not the conventional approach, the argument can be made that not even the "desired traceability relationship" shown in FIGURE 1 is complete because traceability, as it is shown, depends on a long chain of related documents. For example, the Test Procedure (TPR) should be related back to the Tactical Operational Requirement (TOR), which is written in operational user language, if the Test Procedure is to be a true reflection of user requirements. In other words, it should be easy to see how the Test Procedure meets user requirements, rather than trace through several intervening documents in order to discern this relationship. In addition, the intervening document(s) could contain errors, which would cause a distorted view of how the TPR is to meet user requirements.

TABLE 1.

SPECIFIC TRACEABILITY REFERENCES OF 3560.1

IN \ TO	TOR	SOS	SOD	FOS	IDS	PPS	FOD	PDS	PDD	DBD	PP	TPL	TS	TPR	TR	OM	PDM	CSM	SOM
TOR																			
SOS	X																		
SOD	X	X			X														
FOS	X	X	X																
IDS																			
PPS					X														
FOD	X	X	X	X															
PDS			X		X	X	X												
PDD								X		X									
DBD						X		X	X										
PP																			
TPL						X		X					X		X				
TS		X		X				X				X		X	X				
TPR							X					X	X		X				
TR				X								X							
OM																			
PDM			X	X		X		X										X	X
CSM																			
SOM																			

TOR: Tactical Operational Requirement.
SOS: System Operational Specification:
SOD: System Operational Design.
FOS: Function Operational Specification.
IDS: Interface Design Specification.
PPS: Program Performance Specification.
FOD: Function Operational Design.
PDS: Program Design Specificaton.
PDD: Program Description Document.
DBD: Data Base Design.
PP: Program Package.
TPL: Test Plan.
TS: Test Specification.
TPR: Test Procedure.
TR: Test Report.
OM: Operator's Manual
PDM: Program Design Manual.
CSM: Command And Staff Manual.
SOM: System Operator's Manual

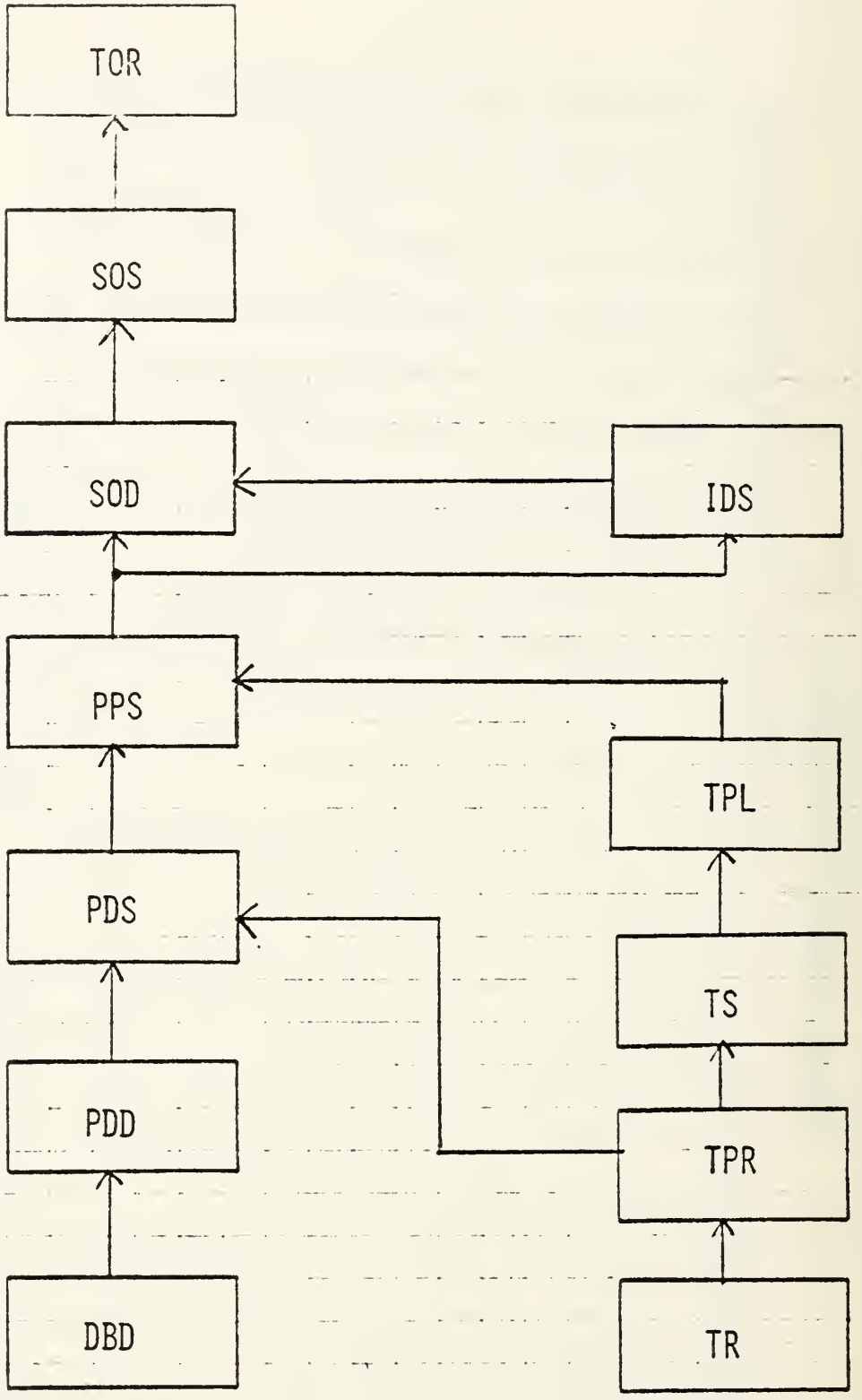

FIGURE 1. DESIRED TRACEABILITY RELATIONSHIP.
* MISSING IN FIGURE 2.

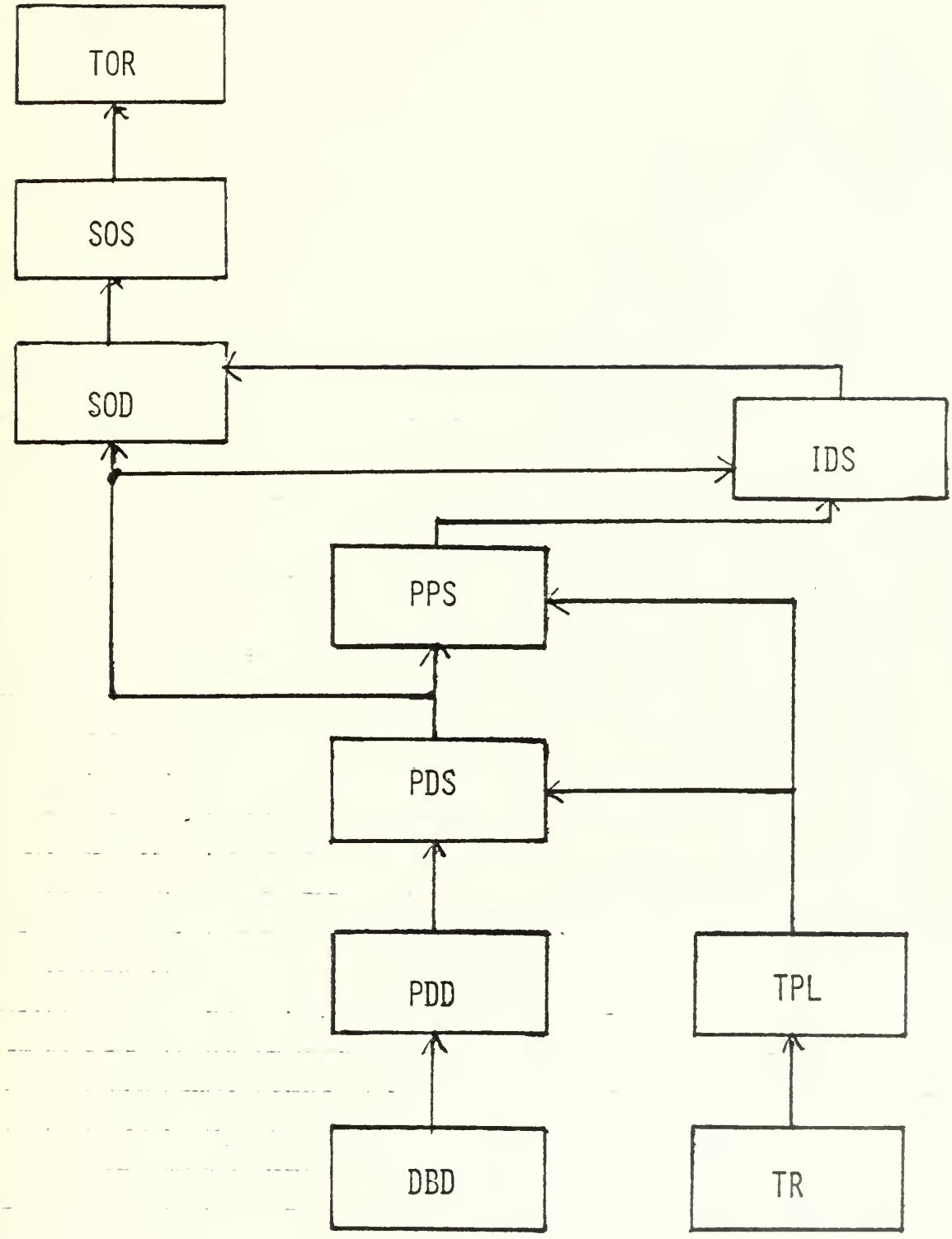

FIGURE 2. ACTUAL TRACEABILITY RELATIONSHIP BASED ON REFERENCES AMONG SECTIONS.

IV. USEFULNESS OF 3560.1 FOR SUPPORTING SOFTWARE MAINTENANCE

Traceability, which was covered in Section III, is a capability which is useful for both software development and maintenance. In this section, a sepcific examination is made of the adequacy of 3560.1 for software maintenance. Each section of 3560.1 that either mentions maintenance or could be useful for software maintenance is analyzed below. Recommendations for improvements in the coverage of software maintenance are noted. Section and page references are to 3560.1.

TABLE 2 is provided to summarize those sections of 3560.1 that are applicable to software maintenance. The table shows section, section number and page references, purpose of the section, and an indication of whether the section is adequate for software maintenance. Brief remarks are given, where appropriate. In the case of negative remarks, explanations are provided following TABLE 2.

1. Tactical Operational Requirement Section 1.5.4 Test Programs, p. 1-13.

Reference is made to any maintenance programs that might be required. The paragraph seems to refer to software that is used to maintain hardware. Specific reference should be made to the need to provide software tools for maintaining software in addition to the software used for maintaining hardware.

2. Interface Design Specification Section 1.0 Purpose, p. 2-41.

This section states: "Upon completion of program development, the Interface Design Specification shall serve as a joint life cycle configuration control device for digital processor program maintenance

of the interface." Except for the section noted in TABLE 2 and the corresponding explanation of remarks, the IDS contains good sections for supporting software maintenance. This is due primarily to the thoroughness of treatment of items, such as signal definitions and inter-processor communications.

3. Program Performance Specification Section 1.0 Purpose, p. 2-83.

This section states: "The Program Performance Specification shall describe in detail all the operational and functional requirements necessary to design, test, and maintain the required digital processor program." As shown in TABLE 2 and the explanation of remarks, there are sections of the PPS which are redundant, unclear, or require more emphasis on validation as opposed to verification. With respect to the last item, see the following section on the Program Description Document, which contrasts validation with verification. The comments in that section apply as well to the PPS. For these reasons the PPS is not entirely adequate for software maintenance.

4. Program Description Document Section 1.0 Purpose, p. 2-137.

This section states: "As a detailed compendium of the subprogram structure, the Program Description document will serve as the essential instrument for subsequent use by operational, maintenance, and contractor personnel diagnosing troubles, making adaption changes, designing and implementing modifications to the system, and in introducing or adding new subprogram functions to the completed program." Thus, the PDD is one of the major documents which govern the conduct of software maintenance. As shown in TABLE 2 and in the corresponding explanation of remarks, the quality assurance provisions of the PDD provide sufficient

emphasis on verifying programs, via testing, but insufficient emphasis on validating programs against tactical requirements (e.g., TOR). As defined by Lewis: "Verification is the iterative process aimed at determining whether the product of each step in the software development cycle fulfills all the requirements levied by the previous step: Does B fulfill requirements of A? Does C fulfill requirements of B, and, implicitly, fulfill requirements of A? . . . . Validation is essentially that part of verification and validation which looks back at the software requirements and determines through testing that they are (or are not) satisfied by the observable system performance indicators. The implication of validation is that the system will meet its operational life cycle design commitments."[1] Thus the PDD is not entirely adequate for software maintenance, although it does contain many comprehensive and detailed sections.

5. Program Package Section 1.0 Purpose, p. 2-165.

This section states: "The Program Package document shall consist of all the program material items necessary for the procuring agency to produce, maintain, and update the digital processor program." Several sections of the PP refer to card decks and magnetic tapes as the media for source programs. These sections should be augmented to allow for the possibility of other physical media, such as disc pack, cassette, cartridge, and ROM. In addition, the possible use of interactive compilation and debugging facilities for software production and the storing

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[1] Robert O. Lewis, "Software Verification and Validation," in John D. Cooper and Mathew Fisher (Editors), Software Quality Management, Chapter 15.

of program files in a time-sharing facility should be recognized. Finally, the document should allow for the possibility of computer to computer transfer of program files, without the intervening physical media of cards and tapes.

6. Operator's Manual Section 1.0 Purpose, p. 4-5.

This section states: "The Operator's Manual shall be limited to instructions for preparing and maintaining the digital processor program in the required state of capability in order that the operational mission may be accomplished." As shown in TABLE 2, there are no sections of the OM that are considered inadequate for software maintenance.

TABLE 2

SUMMARY OF 3560.1 SECTIONS
APPLICABLE TO SOFTWARE MAINTENANCE

INPUTS

SEC	SEC #	PAGE	PURPOSE	*Y/N	REMARKS
FOS	3.3.1	2-37	CHARACTERISTICS	N	UNCLEAR
PPS	3.4.N.1	2-95	CHARACTERISTICS	Y	
PDD	3.4	2-146	FORMATS	Y	
SOM	N	4-38	DATA ENTRY	Y	
			PROCESSING		
FOS	3.3.2	2-37	PROGRAM PROCESSING	Y	
PPS	3.4.N.2	2-98	FUNCTION PROCESSING	Y	
			OUTPUTS		
FOS	3.3.3	2-37	DISTRIBUTION	Y	
PPS	3.4.N.3	2-99	CHARACTERISTICS	Y	
PDD	3.4	2-146	FORMATS	Y	
TS	3.2.4	3-29	TEST OUTPUTS	Y	
			FUNCTIONS		
PPS	3.3	2-90	FUNCTION DESCRIPTION	N	REDUNDANT
PPS	3.3.5	2-92	FUNCTION DESCRIPTION	N	REDUNDANT
PPS	3.4	2-95	FUNCTION REQUIREMENT	N	REDUNDANT
PPS	TABLE 3-11	2-97	FUNCTION VS. STATE	Y	GOOD TABLE
PDS	3.1	2-123	FUNCTION REQUIREMENT	Y	
PDS	3.2	2-124	FUNCTION DESCRIPTION	Y	
PDS	3.4	2-127	FUNCTION FLOW	Y	

*Y/N COLUMN: "Y" MEANS SECTION IS ADEQUATE FOR SOFTWARE MAINTENANCE.
"N" MEANS SECTION IS INADEQUATE FOR SOFTWARE MAINTENANCE.

DATABASE

SEC	SEC #	PAGE	PURPOSE	Y/N	REMARKS
PPS	3.5	2-99	REQUIREMENTS	N	UNCLEAR
PDD	3.3.2	2-145	SUBPROGRAM DATA DESIGN	N	TERMINOLOGY
DBD	ALL	2-153	COMMON DATA DESCRIPTION	Y	

INTERFACES

SOS	5.2	2-14	PERIPHERAL SYSTEM	N	VAGUE
SOS	5.3	2-15	OPERATOR	N	VAGUE
SOS	5.4	2-15	INTERSYSTEM	Y	
SOD	5.2	2-28	PERIPHERAL SYSTEM	Y	
SOD	5.3	2-28	OPERATOR	N	INCOMPLETE
SOD	5.4	2-28	INTERSYSTEM ON-LINE	Y	
IDS	1.0	2-41	INTERFACE REQUIREMENTS	N	CONFUSING
IDS	2.0-8.3	2-42	INTERFACE REQUIREMENTS	Y	GOOD SECTIONS
PPS	3.2.3	2-89	INTERFACE I.D.	Y	
PPS	3.3.3	2-92	DIG. PROC. BLOCK DIA.	Y	
PPS	3.3.4	2-92	PROGRAM	Y	
PDD	3.8	2-149	SUBPROGRAMS	Y	
PDD	FIG. 3-2	2-150	SUBPROGRAMS	Y	

TESTING

PPS	3.4.N.4	2-99	SPECIAL REQUIREMENTS	Y	
PPS	4.2	2-101	TEST REQUIREMENTS	Y	
FOD	5	2-115	TEST & SIM. SCENARIOS	Y	
TPL	1.0	3-5	SCOPE & LEVELS	N	TERMINOLOGY VALIDATION NEEDED
TPL	1.1.2	3-7	EQUIPMENT	Y	
TPL	1.1.3	3-8	SUPPORT SOFTWARE	Y	
TS	3.2	3-23	SYS./PROG. DEFINITION	Y	
TPR	1.0	3-35	INSTRUCTIONS & EVAL.	N	UNCLEAR
TPR	3.2.1	3-40	EQUIPMENT PREPARATION	Y	
TPR	3.2.3	3-41	TEST PROCEDURE	N	UNCLEAR
TPR	7	3-43	SUPPORT SOFT. REQUIRE.	Y	
TR	ALL	3-45	TEST REPORTS	Y	EXCEPT PATCH REFERENCE

QUALITY ASSURANCE

SEC	SEC #	PAGE	PURPOSE	Y/N	REMARKS
PPS	4.	2-100	QA PROVISIONS	N	VALIDATION NEE
PDD	4.	2-149	QA PROVISIONS	N	VALIDATION NEE
TPL	9.	3-14	EVALUATE TEST RESULTS	N	LOOSE
TS	9.	3-26	SPECIFY TEST REPORTS	N	VALIDATION NEE

SUBPROGRAMS & SUBROUTINES

PDS	3.4.3	2-131	REFERENCE CONTROL	Y
PDS	6.	2-133	COMMON SUBROUTINES	Y
PDD	1.0	2-137	SUBPROGRAM STRUCTURE	Y
PDD	3.5	2-148	LIBRARY SUBROUTINES	Y
PDD	3.6	2-148	INITIATION	Y

PROGRAMMING

SOD	6.1	2-29	STANDARDS	Y
PDS	3.3	2-127/8	MEM. & PROC. ALLOC.	Y
PDS	3.5	2-131	LANGUAGE	Y

CAPACITY REQUIREMENTS

FOS	5.2.2	2-39	CONSOLE CAPACITY	Y
PPS	3.5	2-100	PROGRAM CAPACITY	Y

CONFIGURATION MANAGEMENT

SOS	4.2	2-14	PHYSICAL CONFIGURATION	Y
PDS	3.5	2-132	PROGRAM CONFIGURATION	Y
OM	3.1	4-8	MINIMUM CONFIGURATION	Y
PDM	3	4-17	SUBPROGRAM CONFIGURATION	Y

OPERATION

OM	4.3	4-9	PARAMETER VALUES	Y
OM	6	4-9	TROUBLE REPORTS	Y
OM	7	4-10	RECOVERY	Y

INPUTS

Section 3.3.1 (p. 2-37) of FOS reads: "Data type by source, its periodicity of update rate, and expected and/or reliability will be provided in this paragraph." The meaning of the underlined words is unclear.

FUNCTIONS

Sections 3.3 (p. 2-90), 3.3.5 (p. 2-92) and 3.4 (p. 2-95) of PPS overlap to some extent.

DATABASE

Section 3.5 (p. 2-99) of PPS reads: "Adaptation data is that data that can be centrally modified as needed to define the scope of operational functions within prescribed limits." The meaning of this statement is unclear.

Section 3.3.2 (p. 2-145), Variables of PDD refers to "program" in line 2 and "constant" under "a. constant name." The word "variable" was probably intended in both cases.

INTERFACES

Sections 5.2 (p. 2-14) and 5.3 (p. 2-15) of SOS provide insufficient information concerning what comprises a peripheral systems interface and operator interface, respectively.

Section 5.3 (p. 2-28) of SOD references a Peripheral System Interface section 5.2 rather than spelling out what is requred for the Operator Interface.

INTERFACES (CONTINUED)

Section 1.0 (p.2-41) of IDS reads: "This specification establishes a set of requirements for the preparation of a document for defining the design interdigital processor digital interfaces." The underlined portion is confusing.

TESTING

Section 1.0 (p. 3-5) of TPL reads: "The test plan shall define the scope of tests required to ensure that the system, function, and/or program meets all applicable technical, operational and performance specification." Since the only categories of speciation in 3560.1 are "operational," "performance," and "design," the meaning of "technical" is not clear.

Section 1.0c (p. 3-6) of TPL (Function Test) and Section 1.0d (p. 3-6) should stipulate validation against the TOR in addition to verification against performance and design specifications and program description document, respectively.

Section 1.0 (p. 3-35) of TPR reads: "Test procedures provide for the quantitative results of tests, which are later extracted for the tests themselves." The meaning of this statement is not clear.

Sections 3.2.3j (p. 3-42) of TPR reads: "The procedure must agree exactly with the program behavior." The meaning of this statement is not clear.

TESTING (CONTINUED)

Sections 1.1.1 (p. 3-45) and 1. (p. 3-49) of TR imply the allowance of patches in programs during testing. This is believed to be a poor practice.

QUALITY ASSURANCE

Section 4. (p. 2-100) of PPS, Section 4. (p. 2-149) of PDD, and Section 9. (p. 3-26) of TS should stipulate validation against the TOR in addition to program verification.

Section 9. (p. 3-14) of TPL should contain a statement that government personnel must witness the tests. Although this section, as written, is concerned with procurement rather than maintenance, the argument for using government witnesses is valid for maintenance.

V. CONCLUSIONS AND RECOMMENDATIONS

Based on the foregoing analysis, the following conclusions and recommendations are presented relative to the usability of 3560.1 for software maintenance.

1. The standard is comprehensive and detailed. Considering the fact that it was issued in 1974, it was unable to benefit from the hindsight that is expressed in this report, which is based mainly on advances that have been made in programming methodology since 1974. If 3560.1 were updated to reflect new programming technology, it could be a more comprehensive standard than MIL-STD 1679. Notable aspects of the standard are the following:

- Applicable Documents statements.
- Resource budgets (time, space).
- Numerous examples.
- Content Check Lists.
- Interfaces descriptions.
- Test coverage.
- Detailed Table of Contents for each specification.

2. As pointed out in Section III, there are some deficiences in the vital area of traceability.

3. As demonstrated in Section IV, there should be more emphasis on validation. To quote from page 14 of 3560.1: "The Tactical Operational Requirement shall serve as a life cycle configuration management device for specifying the overall tactical operational software capability

requirements for the combat system." That being the case, there should be more emphasis on validating against the TOR, with respect to QA procedures, during both development and maintenance.

4. There are many examples of redundancies and use of inconsistent terminology in the standard. Examples of the former are:

- Section 7. Data Unit Descriptions, p. 2-57 and Section 8. Message Descriptions, p. 2-69 of Interface Design Specification contain similar material.
- Test specification System, pp. 3-20 to 3-26 and Test Specification Function, pp. 3-27 to 3-31 contain similar material.
- Much of the material in the Test Plans and Test Specifications is similar. These could be combined into a single document, with resultant reduction in verbage and increase in clarity.
- Each of the documents is described in the format of purpose, scope, typical content, etc. followed by the actual format of document content. Much of the material is duplicated between the two sections (e.g., Test Procedures pp. 3-35 to 3-37 and pp. 3-39 to 3-42). This material could be combined in many of the documents.

Examples of inconsistent terminology are:

- Section 1.0 Purpose, p. 2-153 and Section 9. Notes, p. 2-162 of Data Base Design refer to a Subprogram Description Document. This document is not defined or described in 3560.1 by that name.
- Section 1.1.3 Analysis, p. 3-46 of Test Reports refers to Operational/Functional Specification. This specification is not defined or described in 3560.1 by that name.

5. The standard is much more oriented to software development than to software maintenance. It also seems to have a strong orientation to the Navy Tactical Data System. A more general orientation might be preferable in order to achieve wider applicability to a variety of software systems.

6. It would be useful for both software development and maintenance activities to provide a section in the standard that describes the material in subject matter instead of document format, i.e., a description of all document sections that refer to inputs, all that refer to outputs, etc. Such a breakdown was used in TABLE 2 of this report.

7. In summary, an inexperienced programmer would probably have difficulty applying 3560.1 to maintenance because of the problems mentioned in this report. Because of the great shortage of skilled software personnel, the criterion of usability of the standard by an inexperienced programmer is appropriate.

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